Understanding the behaviour of organic carbon-14 compounds in contaminated groundwater

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A range of short chain carbon-14 (^{14}C) containing organic compounds can be formed by oxidation of carbides and impurities within nuclear fuel cladding[1]. If leaked to ground there is little data on the persistence of these compounds (including formate; acetate; formaldehyde and methanol) in groundwater environments therefore this work has investigated the fate and behaviour of four model ^{14}C-labelled compounds in aerobic microcosm experiments using glacial outwash sediments and groundwater compositions representative of the UK Sellafield nuclear site[2].

In the experiments the distribution of ^{14}C activities were tracked in each phase: aqueous (liquid scintillation counting); gaseous (by CO_2 capture); inorganic solid (acidification to release gaseous CO_2) and organic solid (oxidation of acidified sample to release gaseous CO_2). In experiments in contact with atmosphere only ~5% of initial ^{14}C remained in solution at the end of the experiments (~300 hours). Loss of formate and acetate can be attributed primarily to microbial metabolism within the sediment. For formaldehyde and especially methanol partial loss by volatilisation may also occur. During aerobic metabolism, short chain organic ^{14}C contaminants are predicted to be oxidised to inorganic species (primarily bicarbonate and carbonate) by dissimilatory metabolism. In subsurface environments this may lead to an increase in carbonate concentrations and so the retention of ^{14}C in solid carbonate precipitates (or by isotopic exchange with pre-existing $^{12/13}C$ carbonate minerals), or, conversely may lead to rapid loss of $^{14}CO_2$ (via exchange with $^{12/13}CO_2$) where good connectivity to the atmosphere is present.

[1] M.S. Yim, F. Caron (2006), *Prog. Nuclear Energy*, **48**, 2-36.[2] M.J. Wilkins, *et al.* (2007), *Geobiology*, **5**, 293-301.